CHAPTER

6

Determination of Red Blood Cell Indices

Learning Objectives

After learning the practical the students should be able to:

1. Explain the significance of determining red blood cell indices.
2. Define and discuss regarding parameters concerned with determining red blood cell indices.
3. Calculate and report the red blood cell indices.
4. Discuss the clinical significance of each red blood cell indices.

Aim of experiment: Determination of red blood cell indices.

Principle: The parameters such as haemoglobin, RBC count, haematocrit value, packed cell volume helps to evaluate certain blood indices which indicate haemoglobin concentration in red blood cell and red blood cell size that aids in accurate diagnosis of the type of anaemia which the patient is suffering from.

Snap box 1

This vital information can be obtained from blood indices:

1. Mean corpuscular volume (MCV)
2. Mean corpuscular haemoglobin (MCH)
3. Mean corpuscular haemoglobin concentration (MCHC)
4. Colour index (CI)
5. Red blood cell distribution width (RDW)

Mean corpuscular volume (MCV) determines the average size of the RBCs; Mean corpuscular haemoglobin (MCH) states the average amount of oxygen-carrying haemoglobin inside a red blood cell; and mean corpuscular haemoglobin concentration (MCHC) denotes the average concentration of haemoglobin inside a red blood cell. The variation in size of RBC can be ascertained by calculating the red cell distribution width (RDW). In pernicious anaemia the variation in RBC size (anisocytosis) along with variation in shape (poikilocytosis) increases the RDW.

Apparatus: Same as that described in chapters of estimation of haemoglobin, RBC count, haematocrit and packed cell volume.

Method

The parameters such as haemoglobin, RBC count, haematocrit value, packed cell volume are calculated by manual method or automated method and red blood cell indices are then determined.

Calculation

1. Mean corpuscular volume (MCV): It is the average volume of single red blood cells. The normal MCV averages in between 78 and 94 μm^3. MCV is increased in pernicious anaemia and megaloblastic anaemia. MCV is decreased in iron deficiency anaemia.

Calculation of the MCV: For example, RBC count is 5 millions/µL of blood; and haematocrit reading is 40%.

$$MCV = \frac{\text{PCV per 100 ml of blood}}{\text{RBC count in millions/µL}} \times 10$$

$$MCV = 40/5 \times 10$$
$$MCV = 80\ \mu m^3$$

Physiological Significance—MCV

A. Macrocytes: When the MCV is higher than normal, the red blood cells are called macrocytes and the clinical condition which patient develops is macrocytic anaemia. The macrocytic anaemia can be caused by: Vitamin B_{12} deficiency, folate deficiency, chemotherapy and preleukemias.

B. Microcytes: When the MCV is lower than normal, the red blood cells are called microcytes and the clinical condition which patient develops is microcytic anaemia. Microcytic anaemia may be caused by iron deficiency (secondary to poor dietary intake of iron, menstrual bleeding, or gastrointestinal bleeding), chronic diseases, thalassemia and lead poisoning.

C. Normocytes: Normocytic normochromic red blood cells are seen in after acute haemorrhage, aplastic anaemia and in all haemolytic anaemia with thalassemia as exception.

2. Mean corpuscular haemoglobin (MCH): This is the quantity or amount of haemoglobin present in one red blood cell. The normal value of MCH averages around 28 to 32 pg (1pg = 10^{-12}).

Calculation of the MCH: For example, RBC count is 5 millions/µL; and haemoglobin level is 15 gm/dl

$$MCH = \frac{\text{Haemoglobin in gm/dl}}{\text{RBC in millions/µL}} \times 10$$

$$MCH = \frac{15}{5} \times 10$$

Thus, MCH = 30 pg or micro microgram.

Physiological Significance—MCH

Decreased MCH occurs in microcytosis associated with chronic infections (microcytic normochromic anaemia) but the decreased in MCH is more significant in iron deficiency anaemia and thalassemia as they are associated with hypochromia.

3. Mean corpuscular haemoglobin concentration (MCHC): MCHC is the concentration of haemoglobin in one red blood cell. It is the amount of haemoglobin expressed in relation to the volume of one red blood cell. The normal value of MCHC is 30% (30 to 38%).

Calculation of the MCHC: For example, haemoglobin level is 15 gm/dl

And haematocrit reading is 40%

$$MCHC = \frac{\text{Haemoglobin in gm/dl}}{\text{PCV per 100 ml of blood}} \times 100$$

$$MCHC = 15/40 \times 100$$

Thus, MCHC = 37.5%

Physiological Significance—MCHC

It is decreased in iron deficiency anaemia in which, red blood cells are hypochromic and microcytic. The increased MCHC may occur during dehydration in patient of hereditary spherocytosis.

4. Colour index (CI): This is the ratio between the percentage of haemoglobin and the percentage of red blood cells in the blood. The normal colour index is 1.0 (0.8 to 1.2).

Calculation of colour index: Haemoglobin is 14.8 µ/dl and RBC count is 5 million/µL of blood.

$$\text{Colour index} = \frac{\text{Haemoglobin\%}}{\text{RBC \%}}$$

Note: For standard reference: Haemoglobin of 14.8 µ/dl is 100%; and RBC count of 5 million /µL of blood is 100%.

Colour index = 100/100 = 1

Physiological Significance—Colour Index

It determines the type of anaemia. Colour index is normal in normocytic normochromic anaemia, lower in iron deficiency anaemia and higher in pernicious anaemia and megaloblastic anaemia,

5. Red blood cell distribution width (RDW): It is an index of the variation in cell volume within the red blood cell population. The normal range of RDW is 11.5 to 14.5%.

The red blood cell distribution width percentage is calculated as follows:

$$RDW\ (\%) = (Standard\ deviation \div mean)\ cell\ volume \times 100$$

Physiological significance: Red blood cell distribution width (RDW): It may be used to quantitate the amount of anisocytosis on peripheral blood smear.

Snap box 2

The first textbook of haematology was written by the French physician Gabriel Andral in 1843 but then the fact that decreased RBC count leads to anaemia was not known. In the early part of nineteenth century, the term anaemia was a clinical term used by physician referring to pallor of the skin and mucous membranes. The technical method for white blood cells count was discovered in 1852 by Karl Vierordt. H. Welcher who was Vierordt's student in 1854, counted the blood cells in a patient with chlorosis and found that an anaemic patient had significantly lesser red blood cells than a normal individual. The clinical and biological science of haematology gain significant importance between 1878 and 1888, when the microscopic details of blood cells could be evaluated. As gradually haematology studies achieved advancement, the blood indices started being used as an important investigation in morphological classification of anaemia.

VIVA VOCE QUESTIONS

Q1. What is mainly indicated by the results of red blood cell indices?

Ans. The red blood cell mainly indicates

a. MCV reveals the average size of the RBCs

b. RDW reveals a variation in size among the RBCs

c. MCHC reveals how much of the cell is being taken up by haemoglobin. Together can reveal anaemia or physiologic disorders that affect quality of life.

Q2. What does increased, decreased and normal MCV indicate?

Ans. *The increased, decreased and normal MCV indicate type of anaemia and is explained below:*

1. **Macrocytic anaemia:** When the MCV is higher than normal the red blood cells are called macrocytes and the clinical condition which patient develops is macrocytic anaemia. The macrocytic anaemia can be caused by: Vitamin B_{12} deficiency, folate deficiency, chemotherapy and preleukemias.
2. **Microcytic anaemia:** When the MCV is lower than normal, the red blood cells are called microcytes and the clinical condition which patient develops is microcytic anaemia. Microcytic anaemia may be caused by iron deficiency (secondary to poor dietary intake of iron, menstrual bleeding, or gastrointestinal bleeding), chronic diseases, thalassemia and lead poisoning.
3. **Normocytic anaemia:** Normocytic normochromic red blood cells are seen in after acute haemorrhage, aplastic anaemia and in all haemolytic anaemia with thalassemia as exception.

Q3. What are the causes for decreased MCH?

Ans. The decreased MCH occurs in microcytosis associated with chronic infections (microcytic normochromic anaemia) but the decreased in MCH is more significant in iron deficiency anaemia and thalassemia as they are associated with hypochromia.

Q4. What are the causes for decreased and increased in MCHC?

Ans. It is decreased in iron deficiency anaemia in which, red blood cells are hypochromic and microcytic. The increased MCHC may occur during dehydration in patient of hereditary spherocytosis.

Q5. What does colour index indicate?

Ans. It determines the type of anaemia. Colour Index is normal in normocytic normochromic anaemia, lower in iron deficiency anaemia and higher in pernicious anaemia and megaloblastic anaemia.

Snap box 3

Nowadays all clinical laboratories prefer using automated machines to perform blood counts, complete blood count which includes red cell indices as part of the profile. Two types of advance automated machines used are Coulter S model which employs the principle of electric impedance; and hemalog system analyzer, which use optical methods in performing cell counts. More advance machines are able to calculate RDW or red cell morphology index, mean platelet volume, differential white cell count and absolute lymphocyte count.

EXERCISE FOR STUDENTS

Spotters—OSPE: Non-Skilled—Calculations

1. **Calculate the MCV from given data:** RBC count is 6 millions/µL of blood; and haematocrit reading is 42%

$$\text{MCV} = \frac{\text{PCV per 100 ml of blood}}{\text{RBC count in millions/µL}} \times 10$$

MCV = … × 10

Thus MCV = … μm^3

2. **Calculate the MCH value from given data:** RBC count is 5 millions/µL of blood; and haemoglobin level is 10 gm/dl

$$\text{MCH} = \frac{\text{Haemoglobin in gm/dl}}{\text{RBC in millions/µL}} \times 10$$

Thus, MCH = … × 10

Thus, MCH = … pg or micro microgram.

3. **Calculate the MCHC value from given data:** For example, haemoglobin level is 15 gm/dl and haematocrit reading is 40%.

$$\text{MCHC} = \frac{\text{Haemoglobin in gm/dl}}{\text{PCV per 100 ml of blood}} \times 100$$

MCHC = … × 100

Thus MCHC = … %

4. **Calculate colour index:** Haemoglobin is 14.8 µ/dl and RBC count is 5 million/µL of blood.
Colour index = Haemoglobin%/RBC %

Note: For standard reference: Haemoglobin of 14.8 µ/dl is 100%; and RBC count of 5 million /µL of blood is 100%.

Colour index = ……

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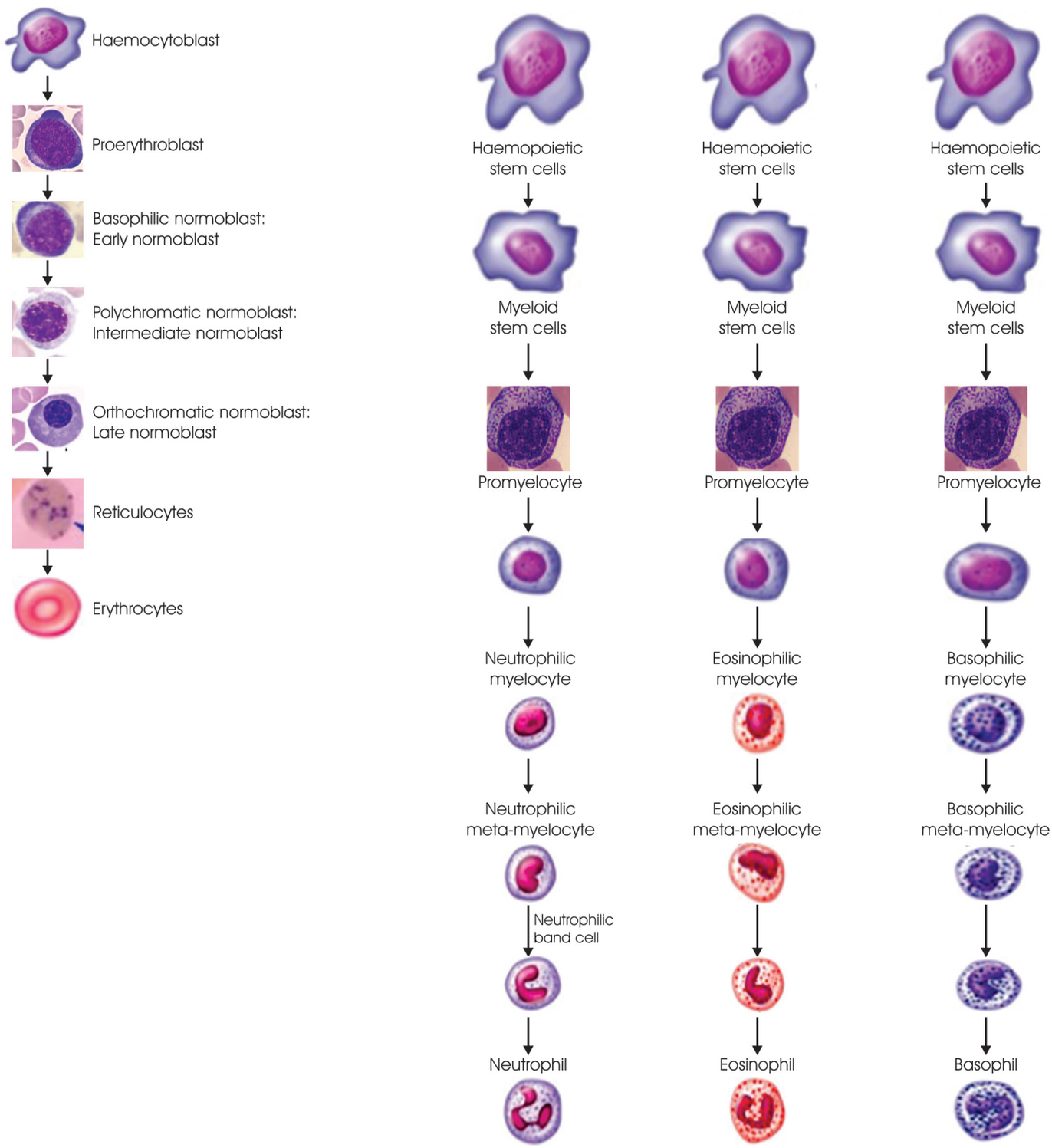
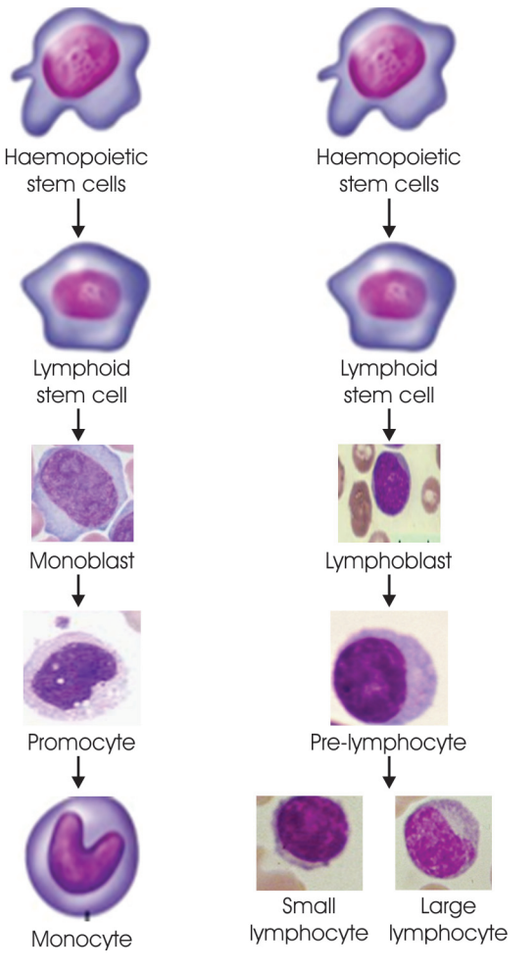
GENESIS OF WHITE BLOOD CELLS AND RED BLOOD CELLS



GENESIS OF MONOCYTES AND LYMPHOCYTES



STRUCTURE OF PLATELET AND ITS GENESIS